AMENDMENT TO THE SPECIFICATION

On page 17, lines 12-23, please replace the following paragraph:

Once the spectrum of the noise frames for the training signal and test signal have been stored at step 304 of FIG. 3, the process of FIG. 3 continues at step 306. In step 306, the means and variances of a plurality of frequency components in the noise of the training signal and in the noise of the test signal are adjusted so that the means and variances are the same in the noise of both signals. This is performed by a spectral adder 516, which accesses the noise segments stored in noise storage 510. The technique for adjusting the means and variances of the noise is discussed further below in connection with FIG. 7.

On page 17, line 24 to page 18, line 8, please replace the following paragraph:

Once the variances and the means of each frequency component of the noise have been matched, the matched training signal is output by spectral adder 516 to a feature extractor 410 of FIG. 4. Feature extractor 410 extracts one or more features from the training signal. Examples of possible feature extraction modules that can be used under the present invention include modules for performing linear predictive coding (LPC), LPC direct cepstrum, perceptive linear prediction (PLP), auditory model feature extraction, and Mel-frequency cepstrum coefficients feature extraction. Note that the invention is not limited to these feature extraction modules and that other modules may be used within the context of the present invention.

On page 19, line 23 to page 20, line 3, please replace the following paragraph:

Step 306 of FIG. 3, which shows the step of adjusting the variances and means of the noise in the training and test signals, represents a step of spectral addition that is performed in order to match the noise in the training signal to the noise in the test signal. Specifically, this step hopes to match the mean strength of each frequency in the noise of the test signal to the mean strength of each frequency in the noise of the training signal and to match the variance in the strength of each frequency component in the noise of these signals.

On page 20, lines 4-18, please replace the following paragraph:

Under most embodiments of the present invention, the matching is performed by first identifying which signal's noise has the higher mean strength for each frequency component and which signal's noise has the higher variance for each frequency component. The test signal and the training signals are then modified by adding properly adjusted noise segments to each signal so that the mean and variance of each frequency component of the noise in the modified signals are equal to the maximum mean and maximum variance found in the noise of either signal. Under one embodiment, a cross-condition is applied so that the noise segments that are added to the test signal come from the training signal and the noise segments that are added to the training signal come from the test signal.

On page 21, line 17 to page 22, line 2, please replace the following paragraph:

The means and variances of the noise may be adjusted independently by adding two different respective signals to both

the test speech signal and training speech signal or at the same time by adding one respective signal to both the test speech signal and the training speech signal. In embodiments where two signals are used, the mean may be adjusted before the variance or after the variance. In addition, the means and variances do not have to both be adjusted, one may be adjusted without adjusting the other. In the discussion below, the embodiment in which two different signals are applied to both the test signal and the training signal is described. In this embodiment, signals to match the variances <u>of the noise</u> are first added to the speech signal and then signals to match the means <u>of the noise</u> are added to the speech signals.

On page 22, lines 3-14, please replace the following paragraph:

The steps for adjusting the variance for a single frequency component <u>of the noise</u> are shown in FIG. 7. The method of FIG. 7 begins at step 700 where the variance of the noise in the training signal is determined. To determine the variance of a particular frequency component in the noise of the training signal, the method tracks strength values (i.e. amplitude values or energy values) of this frequency component in different noise segments stored in noise storage 510 of FIG. 5. Methods for determining the variance of such values are well known.

On page 22, lines 23-30, please replace the following paragraph:

To calculate the complete variance in the noise of the training signal, the strength of the frequency component is measured at each noise frame in the entire training corpus. For example, if the user repeated the identification phrase three

times during training, the variance <u>in the noise</u> would be determined by looking at all of the noise frames found in the three repetitions of the training phrase.

On page 23, lines 10-24, please replace the following paragraph:

Once the variances of the frequency component <u>in the noise</u> have been determined for the training signal and the test signal, the present invention determines which signal has the greater variance <u>in the noise</u> and then adds a noise segment to the other signal to increase the variance of the frequency component in the signal that has the lesser variance <u>in the noise</u> so that its variance <u>in the noise</u> matches the <u>variance in the noise of the</u> other signal. For example, if the variance of the frequency component in the noise of the training signal were less than the variance of the frequency component in the noise of the test signal, a modified noise segment from the test signal would be added to the training signal so that the variance <u>in the noise</u> in the training signal matches the variance <u>in the noise</u> in the test signal.

On page 23, line 25 to page 24, line 9, please replace the following paragraph:

Under one embodiment, the noise segments are not added directly to the signals to change their variance. Instead the mean strength of the frequency component is set to zero across the noise segment and the variance of the noise segment is scaled. These changes limit the size of the strength values that

are added to the test signal or training signal so that the variances in the noise in the test signal and training signal match but the mean strength in the two signals is not increased any more than is necessary. The process of selecting a noise segment, setting the mean of the noise segment's frequency component to zero, and scaling the variance of the noise segment's frequency component are shown as steps 704, 706, 708 and 710 in FIG. 7.

On page 25, lines 15-23, please replace the following paragraph:

The mean strength of the frequency component in the noise segment is subtracted from the frequency component's strength values in order to generate a set of strength values that have zero mean but still maintain the variance found in the original noise segment. Thus, in FIG. 10, the strength of the frequency component continues to vary as it did in the original noise segment, however, its mean has now been adjusted to zero.

On page 25, line 24 to page 26, line 8, please replace the following paragraph:

In step 710, once the values of the frequency component's strength have been adjusted so that they have zero mean, the values are scaled so that they provide a proper amount of variance. This scaling factor is produced by multiplying each of the strength values by a variance gain factor. The variance gain factor, G, is determined by the following equation:

$$G = \frac{\left|\sigma_{TRAIN}^2 - \sigma_{TEST}^2\right|}{\sigma_{NOISE}^2} \qquad \text{Eq. 1}$$

where G is the variance gain factor, σ_{TRAIN}^2 is the variance in the noise of the training signal, σ_{TEST}^2 is the variance in the noise

of the test signal, and σ^2_{NOISE} is the variance of the values in the zero-mean noise segment produced at step 708.

On page 26, line 16 to page 27, line 7, please replace the following paragraph:

After step 710, the modified frequency component values of the noise segment have zero mean and a variance that is equal to the difference between the variance of the training signal and the variance of the test signal. Thus, the modified values can be thought of as a variance pattern. When added to the signal with the lesser variance in the noise, the strength values of this variance pattern cause the signal with the lesser variance in the noise to have a new variance in the noise that matches the variance in the noise of the signal with the larger variance in the noise. For example, if the test signal had a lower variance in its noise than the training signal, adding the variance pattern from the training noise segment to each of a set of equally sized segments in the test signal would generate a test signal with a variance due to noise that matches the higher variance in the noise of the training signal. The step of adding the variance pattern to the strength values of the test signal or training signal is shown as step 712.

On page 27, lines 8-12, please replace the following paragraph:

Note that for the signal with the higher variance in the noise, the variance gain factor is set to zero. When multiplied by the strength values of the noise segment, this causes the modified noise segment to have a mean of zero and a variance of zero.

On page 27, line 13 to page 28, line 5, please replace the following paragraph:

Note that because of the subtraction performed in step 708, the test signal or training signal produced after step 712 may have a negative strength for one or more frequency components. For example, FIG. 12 shows strength values for the frequency component of either the test signal or training signal, with time shown along horizontal axis 1200 and strength shown along vertical axis 1202. Since the strength values in FIG. 12 are taken from an actual test signal or training signal, all of the strength values in graph 1204 are positive. However, FIG. 13 shows the result of the addition performed in step 712 where the strength values in segments of the test signal are added to respective strength values of the variance pattern shown in FIG. 11. In FIG. 13, time is shown along horizontal axis 1300 and strength is shown along vertical axis 1302. Graph 1304 of FIG. 13 represents the addition of graph 1104 of FIG. 11 with graph 1204 of FIG. 12. As shown in FIG. 13, graph 1304 includes negative values for some strengths of the frequency component because the variance pattern included some negative values after the mean <u>of the noise segment</u> was subtracted in step 708.

On page 28, lines 6-13, please replace the following paragraph:

Since a negative strength (either amplitude or energy) for a frequency component cannot be realized in a real system, the strength values for the frequency component in the test signal and training signal must be increased so all of the values are greater than or equal to zero. In addition, the strength values must be increased uniformly so that the variance <u>of the noise in the two signals</u> is unaffected.

On page 28, line 23 to page 29, line 2, please replace the following paragraph:

FIG. 14 provides a graph 1404 of the signal of FIG. 13 after this addition, showing that the strength for the frequency component now has a minimum of zero. In FIG. 14, time is shown along horizontal axis 1400 and strength is shown along vertical axis 1402. Since the strength value added to each of the strength values is the same, the variance of the noise in the test signal and training signal are unchanged.

On page 29, lines 3-9, please replace the following paragraph:

Note that the strength value must be added to both the test signal and the training signal regardless of which signal had its variance increased. If this were not done, the mean of the noise in one of the signals would increase while the mean of the noise in the other signal would remain the same. This would cause the means of the noise to become mismatched.

On page 29, lines 10-20, please replace the following paragraph:

In FIG. 7, the step of adjusting the modified test signal and training signal to avoid having negative values in those signals has been shown as occurring before the means of the noise of the two signals have been matched. In other embodiments, this step is performed after the means of the noise have matched. One benefit of waiting to adjust the signals for negative values until after the means of the noise have been matched is that the step of matching the means of the noise may cause the signals to be increased to the point where they do not include any negative values.

On page 29, lines 21-24, please replace the following paragraph:

After step 716, the variances of the noise of the test signal and the training signal are matched and each signal only has positive strength values for each frequency component.

On page 29, line 25 to page 30, line 5, please replace the following paragraph:

Note that the steps of FIG. 7 are repeated for each desired frequency component in the test signal and training signal. Also note that the variance of the noise for some frequency components will be higher in the test signal than in the training signal, while for other frequency components, the variance of the noise in the test signal will be lower than in the training signal. Thus, at some frequencies, a variance pattern formed from a ~~of the~~ noise segment will be added to the test signal, while at other frequencies, a variance pattern formed from ~~the~~ a noise segment will be added to the training signal.

On page 30, lines 6-17, please replace the following paragraph:

Once the variances in the noise of the training signal and test signal have been matched, the means of the strength values in the noise of the two signals are matched. This is shown as step 308 in FIG. 3 and is shown in detail in the flow diagram of FIG. 15. As in the method of FIG. 7, the steps for matching a mean strength of the noise shown in FIG. 15 are repeated for each frequency component of interest in the noise of the test signal and training signal. Consistent with the discussion above, the mean strength of the noise can either be the mean amplitude or the mean energy, depending on the particular embodiment.

On page 30, line 27 to page 31, line 2, please replace the following paragraph:

In step 1504 of FIG. 15, the difference between the means in the noise of the test signal and the training signal are determined. This involves simply subtracting the mean strength of the noise of one signal from the mean strength of the noise in the other signal and taking the absolute value of the result.

On page 31, lines 3-22, please replace the following paragraph:

In step 1506, the signal with the lower mean in the noise has all of its strength values for the frequency component increased by an amount equal to the difference between the means of the noise in the test signal and the noise in the training signal. This can be seen by comparing FIGS. 16 and 17. In FIG. 16, graph 1604 shows the strength of a frequency component of the test signal or training signal as a function of time. In FIG. 16, time is shown along horizontal axis 1600 and strength is shown along vertical axis 1602. FIG. 17 shows the same frequency component for the same signal after the difference between the means in the noise of the test signal and training signal has been added to the signal of FIG. 16. Thus, graph 1704 of FIG. 17 has the same shape of graph 1604 of FIG. 16 but is simply shifted upward. This upward shift does not change the variance in the noise, but simply shifts the mean of the frequency component across the signal. Thus, the variances in the noise continue to be matched after the steps of FIG. 15.

On page 31, line 23 to page 32, line 2, please replace the following paragraph:

Note that for some frequency components, the mean of the frequency component in the noise in the test signal is

greater than the mean of the frequency component in the noise in the training signal while at other frequencies the reverse is true. Thus, at some frequencies, the difference between the means of the noise is added to the test signal while at other frequencies the difference between the means of the noise is added to the training signal.

On page 32, lines 3-17, please replace the following paragraph:

As mentioned above, in alternative embodiments, only one respective noise signal is added to each of the training signal and test signal in order to match both the variance and means of the noise of those signals. Thus, one noise signal generated from a training noise segment would be added to the test signal and one noise signal generated from a test noise segment would be added to the training signal. Under one embodiment, the one noise signal to be added to each speech signal is formed by adding the difference between the means of the noise to all of the values of the variance pattern of the signal with the lower mean in the noise. The resulting mean adjusted variance pattern is then added to its respective signal as described above.

On page 32, line 27 to page 33, line 11, please replace the following paragraph:

Multiple training signals can be dealt with in several ways. Two primary ways are discussed here. First, if all the training signals are considered to have been generated in the same noisy environment, they can be considered to be one training signal for the above description. If they might have come from separate noisy environments, such as would occur if they were recorded at separate times, the above description would simply be extended to multiple signals. The mean and variance of each

frequency of the noise of all signals would be appropriately adjusted (through adding noise from the other conditions) to have the maximum mean and variance at each frequency <u>in the noise</u> of any of the multiple signals.